SYSTEM ARCHITECTURE DEVELOPMENT FOR ATT IN EUROPE AND IVHS IN THE USA

Ronald C. Heft, Program Manager, National IVHS Architecture Development Program, Jet Propulsion Laboratory
Bob McQueen, Associate Director, Halcrow Fox

525 School Street SW, Suite 203
Washington DC 20024
USA

Vineyard House, 44 Brook Green,
Hammersmith, London W6 7BY
England

ABSTRACT

Europe has taken an early lead in the development and deployment of All applications through the adoption of relatively narrow, ad-hoc architectures. These tend to be application-specific and the approach has facilitated rapid development. Meanwhile the US is developing a single national IVHS architecture funded and directed at national level by USDOT. This paper provides a brief description of both European and US system architecture development approaches and makes some preliminary comparisons and observations.

1. INTRODUCTION

There is a growing debate in ATT and IVHS circles regarding the relative merits of the European approach to ATT system architecture development and the US approach to the development of IVHS, or Intelligent Transportation System (ITS) architecture. In very simplistic terms, the European approach could be categorised as 'bottom-up' with a large range of independent, tightly focused architectures, or sub-architectures, developed within a loose consensus framework. These architectures have been developed for specific applications, or for specific cities or regions, within a context of relatively iow levels of central funding and significant local investment.

The US approach could be categorised as 'top down' with an attempt to define a single national architecture through the execution of a large, centrally funded and directed programme of activities,

in fact, a closer investigation of both approaches reveals that the practical situation is not quite so black and white. The US IVHS program actually started in a 'bottom-up' mode, while the European approach has significant 'top down' elements,

This paper explores some of the most significant features of each approach, making preliminary comparisons and observations which may prove valuable and perhaps facilitate further cooperation in this pivotal area of ATT and IVHS.

2. EUROPE

2.1. Background

It is a common misconception, in the rest of the world, that the European Community and it's institutional system operates in the same manner as the US Federal system, This is definitely not the case. The EC is not a true federation as the national governments and parliaments of the EC member states are not subordinate in many significant areas. The EC is a loose framework of nations cooperating in areas of mutual interest and benefit, as the states do in the USA. However EC member states will often exercise the right to work independently towards specific objectives which satisfy regional and national self-interest. Cooperation, when it does take place, is as the result of consensus formation and 'soft' agreement, rather than 'hard' legislative requirements.

This ability to put national interest ahead of pan-European has meant that market fragmentation has always been a factor in the European context. Markets for most goods and products have tended to be national rather than European with products and services designed for national markets rather than the European market. The need for consensus and agreement before pan-European cooperation can be achieved sometimes results in the adoption of compromise approaches to the organisation and management of research and development programmed. In some cases, it could be argued that more resources and effort are expended in developing a single European view than on the research and development topics themselves,

it may weii be the case that we are witnessing the embryonic stages of a fully fledged European federation of states, comparable to the USA, but it is too early to make a judgement on this.

2.2. European Approach

The development of system architecture in Europe is inextricably linked to ATT development and implementation initiatives. During the last five years in particular, there has been significant progress in Europe towards the widespread implementation of ATT/IVHS. The dawn of European interest in the application of ATT/IVHS can be traced back to the LISB project in Berlin (Leit-und Information-System Berlin). This was initiated in the 1980's as a large scale field trial of the Siemens ALI-SCOUT technology. Around the same time, the Commission of the European Communities (CEC) carried out pilot investigations to assess ATT/IVHS development across Europe, This led to the establishment of the DRIVE I programme.

It could be argued that the genesis of ATT/IVHS lay in the US in the early 1970's, with the Federal Government's active support role in civilian technology development, At the same time corresponding work had begun on the Autofarer Leitung und information System (ALI) Program in Europe, and the Japanese CACS Program me (Comprehensive Automobile Traffic Control System). As the Federal Government pulled out of direct civilian support in the U.S. in the 1980's, further development of IT applications to transport were concentrated on Europe and Japan.

The pace has been set in Europe by the initiation of co-operative research and development programmed. The most influential of these have been the PROMETHEUS and DRIVE programmed, initiated in 1986 and 1988 respectively.

A central theme of the European effort in DRIVE 1 was the initially strong influence of central government in the form of the CEC, who invested funds in cooperative research programmed, encouraging pan-European participation and multi-disciplinary working. While the DRIVE Programme addressed ATT generally, the major European vehicle manufacturers proceeded, within the PROMETHEUS programme, with the complementary development of in-vehicle systems. This led to the current situation where preparations for large scale implementation are being made,

The DRIVE II programme was initiated in January 1992. This involves a programme of medium to large-scale pilot projects in urban and inter-urban contexts, in order to gain experience in practical implementation of ATT/IVHS technologies. This should in turn lead to wide-scale ATT/IVHS implementation in Europe in the late 1990's.

A major feature of European research and development has been the co-ordination and cm-operation achieved across national and disciplinary boundaries. A great deal of research effort has been invested in the definition of common functional requirements and system architecture needs. The concept of an integrated Road Traffic Environment (IRTE), supporting separate applications and systems from competing suppliers has been central to the development effort.

The strategy has been to define a common framework, within which development can take place. The goal is to enable rival systems to coexist and utilise common infrastructure and architectures. This should ensure that duplication of development effort and infrastructure provision is avoided, while creating a healthy, competitive market place.

More recently, city authorities across Europe have expressed interest in ATT/IVHS implementations as a means of managing traffic problems in urban areas. Through the auspices of the POLIS initiative, most of the major European cities are now reacting to the iead taken by central government. Thus the rapid growth of interest is developing other influences in the implementation of AT T/IVHS, with the cities proposing implementations aimed at solving local problems. This situation has strong parallels with that in the US.

The European ATT programme has always had a significant 'top down' element, The initial DRIVE 1 programme was initiated centrally by the CEC and include a major project addressing system architecture development. This project, known as SECFO, or System Engineering and Consensus Formation Office, played a central role in DRIVE 1 and carried out much of the work which provides a foundation for the current European approach, Within DRIVE 2, the SECFO mantle was assumed by Topic Group 10 within the DRIVE Concertation framework and, more recently, this has been complemented by an ERTICO task force known as SATIN. SATiN (The IRTE System Architecture and Traffic control integration task force) was inaugurated on 31 January 1994.

The purpose of SATIN is to develop a common methodology for system architecture design, and to provide implementing actors with a comprehensive set of traffic system architecture descriptions and guidelines to use as the basis of local architecture development and assessment.

The work covered by SATIN includes the following:

define and recommend architectural design methodologies (functional and information architectures)

define and recommend architecture development tools

develop sets of functional architectures (urban and inter-urban)

develop sets of logical architectures (urban and inter-urban)

This work is to be carried out for 6 selected CORD Areas. The work of the Task Force has been deliberately limited in scope, with the intention that most of the architecture development work will continue within the various DRIVE projects, with discussion of common issues and consensus formation carried out at Topic Group Level (TG1 O). SATIN will not propose detailed hardware and software design (ie it is not a technical architecture) but is based on the higher level architectural concepts coming out of the participating DRIVE projects (GERDIEN, LLAMD, EUROBUS, PASSPORT, QUARTET, IFMS, and GAUDI). SATIN will not include institutional or legal issues associated with functional or information architectures.

SATIN has been organised as 7 sub-groups as follows:

automatic debiting systems
urban traffic management
inter-urban traffic management
travel and traffic Information
freight and fleet management (including Hazardous Goods)
public transport
methodology

The first 6 sub groups listed above address CORD ATT functional areas, The seventh group (methodology) is charged with defining and recommending a methodology for the design of functional and information architectures for ATT/IVHS (SATIN defines information architectures as 'conceptual data models'). The methodology will be in the form of a bcok of rules of best practice architectures, and will act as a guideline for participation in architectural development within the '4th Framework, The initial view is that 6 deliverables wiil be produced as follows:
recommendations for design methodology and tools

reference functional and information architectures for the 6 Areas (described using the CORD area and functional definitions only)

'global' functional urban and inter-urban architectures

"global' information urban and inter-urban architectures

description of integrated urban and inter-urban architectures

summary report providing guidelines for IRTE architecture design

SATIN is expected to be complete by December 1994, and its results will be forwarded to CEN TC278 for standardisation.

As discussed earlier, architectural development is inextricably linked to the various All_ initiatives. There is a wide range of activity associated with various European projects. Some of the most significant of these are listed as follows:

COMFORT
STORM
The 5T Project
GAUDI
SOCRATES
FEDICS/CITRAC
Gerdien
Euro-Scout
RDS-TMC

This is not an exhaustive list. These projects are not described in this paper as they have been given adequate coverage in other publications from the Transport Telematics Office (see also reference [1]), It is sufficient for the purposes of this paper to note the work carried out in these projects and emphasise the diverse nature of ATT system architecture development in Europe.

3. USA

3.1 Background

The US IVHS architecture development program is a public/private initiative. The architecture development activities were initiated by the Intelligent Vehicle Highway Society of America (IVHS AMERICA), In its congressionally chartered role as an advisor to the United States Department of Transportation, the societ y's first action was to request that USDOT develop a national IVHS system architecture. The architecture development program is funded and facilitated by the USDOT Joint IVHS Program Office. While USDOT is the facilitator for the architecture, it is not the owner of the architecture.

The architecture must find ownership not by USDOT, but by the cities, states, regional transportation jurisdictions, motoring public, truck operators, and by the providers of services and products.

For the architecture to be successful, it must be reviewed, critiqued, and agreed upon by key stakeholders, both in the public and private sectors.

To achieve the benefits of a national IVHS architecture, USDOT adopted a very specific program strategy. This strategy is composed of four basic tenets. The first is to establish a top-down architecture, based upon national goals and common national user requirements. The public/private partnership between USDOT and IVHS AMERICA has succeeded both in definition and agreement upon national goals and user requirements for IVHS. It was decided at the onset to ensure that the architecture development program would be responsive to these goals and requirements. Second, the strategy was designed to ensure participation by the proponent key stakeholders.

For an architecture to be successful, it needs to be accepted by those who are affected by it and by those who will be the proponents for its services and products, To achieve these ends, the active, direct participation of the potential producers and the key affected parties was deemed to be necessary. Third, the strategy is designed to explore a variety of architectural approaches, Many different ways of implementing IVHS systems (singularly and in combinations) have been proposed and discussed. To ensure that we could have agreement on a single national approach, it was necessary to explore each of the major architectural approaches. Finally, a strategy was needed to focus on one technicality sound national architecture that had the consensus support of the builders, the buyers, and the users.

3.2 US Approach

A specific implementation strategy was identified for the IVHS architecture. This implementation involved establishing participation of key industry elements by requesting and responding to their comments upon the proposed development approach that USDOT was following. Following their responses, the basic method was then adjusted and modified to accommodate the needs of industry. The solicitation for the performance of the architecture development was then focused upon teams composed of proponents of IVHS systems. Since these would be the firms and companies that would provide IVHS systems In the United States, it was felt that they were the proper ones to be directly Involved in the development of the IVHS architecture. A two-phase program was developed. In Phase 1, four teams would define and evaluate architecture evolving over a 15-month period.

The four teams represent a consortia from industry, state and local government, and the academic community. Each team is led by a nationally known firm: Hughes Aircraft company, Loral Federal Systems, Rockwell International, and Westinghouse Corporation, Each of the teams proposed a different architectural approach for IVHS, and each of the teams was technically strong. Following Phase 1, USDOT, working with key affected stakeholders, would then select the most promising architectures to pursue into Phase II. Phase II would then involve the final definition and evaluation culminating in one single, national architecture. To achieve this implementation, USDOT structured a specific organization for technical review, engineering management, and consensus development.

The organization for developing the US IVHS architecture is led by the USDOT architecture team composed of representatives from the various modal administrations.

The Jet Propulsion laboratory is the architectural manager for USDOT and handles the day-to-day technical management of the four architecture development teams. USDOT, working collectively with IVHS AMERICA has established a consensus building team. This team is responsible for establishing the regional meetings, the focus groups, the task forces, and interfacing with the IVHS AMERICA committees. To ensure the technical soundness of the architecture, USDOT has established a Technical Review team, composed of leading experts in IVHS and IVHS systems in the United States.

Starting with multiple architectural concepts, and ultimately focusing down on a single national architecture, a two-phase program was established. Phase I started in September of 1993 with a duration of 16 months, and was subject to proprietary non-disclosure agreements to permit private firms to fully discuss and examine architectures which may involve proprietary products. Within Phase 1, there is a detailed technical review process, led by the Technical Review teams and the initiation of the consensus activities, with both consensus task force and regional meetings.

Phase I concludes with the provision of the final report documentation and program review in October of this year, Phase I will provide deliverable documentation both defining and evaluating each architecture. The definitional documentation will include a Mission Definition, a Logical Architecture and a Physical Architecture, Evaluation of each architecture will entail a communications loading analysis, a performance and benefits examination, a feasibility and risk analysis, an examination of the cost and economics, and finally, an evolutionary deployment strategy. These Phase I documents were made available to USDOT on the 3rd of October, and made available to the public shortly thereafter.

Phase II of the architecture development will be nineteen months in duration starting in about February of 1995. The major thrust of Phase II will be to develop a progressive consensus to achieve a single national architecture. In Phase II, several teams will continue the definition and refinements of the architectures, their evolutionary deployments, and their evaluations. Unlike Phase 1, these results will be open to the public. There will be no proprietary restrictions, Throughout Phase II, extensive public reviews will be held and key stakeholders and affected parties will be invited to participate directly with the teams in the development and agreements of the national architecture. This process will result in the emergence of a national IVHS architecture by July of 1996.

In establishing the architecture development program, a set of formal documents was established to define an IVHS architecture. There is a structured, specific relationship internally among the documents and the implementation of IVHS systems.

Those documents which define the IVHS Architecture are: the mission definition, the logical architecture, and the physical architecture:

The mission definition establishes the top level goals and requirements, the logical architecture identifies the what, and the physical architecture identifies the how. The mission definition contains the user requirements, the national goals, the operational requirements and a statement of the vision of an IVHS architecture as it would be when systems and products were fully deployed sometime in the future.

The second of these documents is a logical architecture document. This is a formal system engineering document that contains data and control flow diagrams, and descriptions of functional and process depictions. The logical architecture document describes exactly what an IVHS architecture should accomplish,

It does not describe how it is done. The third document is the physical architecture document, The processes and functions described in the logical architecture are mapped onto physical entities. The entities related to each other through physical interconnections and physical flows of data and control information.

Those three documentations are independent of any specific implementation or deployment. Specific deployment designs can be established consistent with the physical architecture. These deployment designs are specific to and dependent upon the time at which they are developed, and the location where they are developed. A specific deployment of the national architecture for an urban city will be quite different from a deployment of the architecture for a rural area. Both of them, however, can be consistent with a single physical architecture.

The US program adopted a top-down process for the development of the IVHS architecture. The mission definition document contains the goals and the requirements for the IVHS system architecture, The logical architecture responds to those requirements in the mission definition with specific functional processes and functional flows. Each of the requirements within the mission definition needs to be supported by these processes and flows which occur within the logical architecture. This encourages early assessment of potential problems in user services requirements support and integration.

The physical architecture Is responsive to the requirements of the logical architecture. Each of the logical processes and flows contained within the logical architecture must be mapped and embodied in the physical elements of the physical architecture. To fully evaluate an architecture, it is necessary to go beyond the physical architecture, Issues of cost, and operational performance can only be effectively addressed by looking at specific deployments of systems in the context of an architecture. Each of the architecture development teams develop candidate deployment designs for specific regions and for specific time frames. These deployments are then subject to architectural evaluation from the standpoint of cost, feasibility, risk and performance.

This formal top-down process, with its associated documentation permits the architectures being proposed by the various teams to be evaluated for technical feasibility in some detail. One of the hallmarks of the US architecture development program has been the degree of technical review that has been performed on these architecture definition and evaluation documents. Over the course of Phase I there have been hundreds of pages of review comments provided back to the architecture development teams, This plan of careful documentation and detailed review will help ensure that the resulting final national architecture is technically feasible.

A proposed architecture, even if technicality optimal would be unsuccessful if it is not implemented, In fact, one of the guiding statements for the development of the US architecture program has been, “The best architecture is the one that will be implemented.” To develop a successful architecture, it is necessary to go beyond technical feasibility and to address the acceptability and the desirability of both the architecture and the results of the use of that architecture by key affected parties. USDOT established a consensus building program by support of this requirement.

The goals of this program are to develop a public awareness, understanding, and acceptance of IVHS and the IVHS architecture program.

Key to these goals are to address the key stakeholders' concerns early in the process. Starting in about the middle of Phase 1, architecture information was provided to stakeholders, their concerns were reviewed, and provided to the architecture development teams, so that they could make adjustments and modifications in their architecture approach. Between Phase I and Phase II a selection process will occur, which attempts to pick the best and the strongest of the approaches 10 continue into Phase II. That down-select process is supported directly by a technical review and by the consensus activities and bytheresporrse and observations of the key stakeholders. Within Phase II, the final architecture syntheses will be guided by the positions and choices made by the key stakeholders.

3.3 Consensus Support

There are two principal means for establishing consensus support. The first is a consensus task force, and the second is a sequence of regional consensus meetings. The consensus task force was established as a forum for national stakeholders to review and comment on the developing architectural alternatives, It is composed of approximately 40 volunteers representing key stakeholders from the public sector, the private sector, and special interest groups, This consensus task force meets after major program reviews. They discuss the architectural alternatives and provide their positions back to USDOT. The second major consensus element is the regional meetings,

The purpose of the regional meetings is to disseminate information and to obtain the local perspectives on the developing architectural alternatives. After each of the major program reviews, public meetings have been, and will continue to be held in the ten USDOT regions in the United States. These regional meetings include presentations by the architecture development teams and then an interactive set of questions and answers from people within the audience. These provide direct feedback to the architectural development teams. In addition,, USDOT prepares a detailed set of notes from these meetings,

At the culmination of Phase II, there will be a set of defined products of the architectural development program. The first of these will be the definition of the architecture itself, comprised of the mission definition, the logical architecture, and the physical architecture document. Second will be the evaluation of that architecture from the standpoint of cost, benefits, communications loading and evolutionary deployment. The final documentation will also directly address what is necessary to support the implementation of the architecture from the standpoint of research and development needs, operations tests that need to be conducted, and standards that need to be developed. However, the most important product of the architecture development program is not the documentation. The important product is the national agreement on this framework for implementing IVHS. It is this national agreement that will ensure national compatibility, enable the national markets, and provide the foundation for the development of national standards.

4. COMPARISONS AND OBSERVATIONS

4.1 European Approach

It is very difficult to summarise the current European situation in a short paper such as this. There are many initiatives, with large resources committed to diverse objectives. Many of these objectives are local and regional rather than pan-European in nature, having been influenced by relatively large amounts of locally derived funding, thus swinging the balance towards local objectives,

Where activity is directed towards pan-European objectives, the emphasis has tended to the needs of specific applications such a route guidance, travel information or electronic transaction management. The relatively iow level of centrally derived resources makes it difficult to achieve pan-european consensus on these matters.

A further complication in the attainment of European consensus is found in the nature of the European political context. The relatively weak nature of the European Union forces the adoption of soft consensus formation, rather than central direction of the consensus process.

4.2 US Approach

Although it is widely perceived as a 'top down' approach, the US IVHS program " initially set out as a 'bottom up' approach incorporating a wide variety of disparate initiatives. There has been a relatively large amount of centrally-derived investment sourced mainly from the Federal Government. However, due to the nature of the American political process, there has also been much local direction of funds aimed at satisfying local objectives, The funding process has been much more intense than Europe, with larger sums of money committed over shorter time periods.

With regard to the development of system architecture, the US approach has most definitely 'top down' with large central funding and tight centrally controlled direction of the programme. This has apparently enabled the US to involve the major stakeholders in an efficient effective fashion and deploy the 'cream' of US defence contractors, aerospace companies and research institutions at a very early stage. The multiple team approach, with parallel effort from four independent consortia has enhanced this process.

Another important effect of the US approach is the necessity to address legal, institutional, organisational and market acceptance issues at an early stage in the architecture development process. To some extent, the narrower European focus has accelerated technical development by decoupling the need to address such issues, but such issues still have to be addressed in migrating towards more comprehensive solutions.

It is also important to note that the early definition of a widely accepted national system architecture was driven, to a large extent, by commercial objectives. The US believes that the lion's share of implementation and hence business opportunities will faii to the private sector, Consequently, it is expected that the largest proportion of funding for deployment will come from private sector resources. in order to invest with confidence, the private sector needs component and interface standards and a clear picture of how all the various parts work together to form the whole.

4.3 Summary

It would be premature at this stage to conclude that either of the approaches described is the better. Both approaches have particular attractions and negative aspects. These will, over the course of time, influence success or otherwise. The next year will be crucial in determining the efficacy of each approach,

It can be concluded that the US National IVHS Architecture Development Program has successfully accelerated the acquisition of knowledge, expertise and experience in key US industries. This combined with the effects of the IVHS program as a whole has enabled the US to move forward, in a relatively short time, to level terms, if not slightly ahead of Europe in many aspects of ATT/IVHS.

Europe now faces an international challenge in the race to deploy the results of the many years of research 'and development. This could have a beneficial effect for both Europe and the US, if Europe responds in a positive manner. There is much to be gained through closer international cooperation at this stage in the development of ATT and IVHS. There is a great opportunity to pool expertise and experience as a way of moving the international ATT/IVHS community to the next stage in development.

An interesting aspect of this is the identification of common trends, problems and experiences at an international level. There are many common lessons being iearned on both sides of the Atlantic. These include a growing recognition that most problems are institutional and organisational not technological. This is combined with a wider acceptance that 'technology push' must give way to 'end user pull' through the definition of user services and functional specifications through transportation policy matching techniques,

Another commonly heid belief is that the identification of public/private interfaces and development of appropriate cooperation mechanisms is essential to successful wide scale deployment.

There is also wide international recognition of the role that system architecture development will play in standardisation and the need for international standardisation as a prerequisite to the exploitation of global market opportunities.

As our knowledge grows and our view of technology capabilities and impacts matures, we are also coming to recognise the need to involve a wider community and provide intelligent transportation systems which have a more holistic nature, integrating air, iand and sea transportation modes for both passengers and freight.

Finally, we are also, on an international scale, coming to recognise the important link between regional development and transportation policy and in turn the relationship between economic development and the implementation of multi-modal intelligent transportation systems.

The above factors all point to the potential for international cooperation and synergy, rather than independent and isolated development.

5. REFERENCES

[1] A Review of European Advanced Transport Telematics System Architecture Development, by Bob McQueen and Paul Taylor, Halcrow Advanced Transport Technology Group, Vineyard l-louse, 44 Brook Green, London, England, July 1994